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Smart City Development Frameworks: A Systematic Literature Review of Publication Patterns, Technology Implementation, and Research Impact

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Abstract. The development frameworks for smart cities have significantly advanced over the past decade, driving urban sustainability, efficiency, and technological integration. This study systematically reviews 18,309 scientific articles from IEEE Xplore, Web of Science, Scopus, EBSCOhost, ProQuest, and ScienceDirect databases, refined using PRISMA criteria, resulting in 65 high-impact publications. Analysis indicates that Q1 and Q2 journals dominate this research field, reflecting the high academic relevance and rigorous quality standards in studies related to smart urban development. Sustainability, Sensors, and IEEE Access emerged as the most influential journals, highlighting interdisciplinary approaches and technological innovations. European nations, particularly Germany, Switzerland, and Poland, lead international collaboration networks, demonstrating strategic research alliances in urban innovation. Technologically, the Internet of Things (IoT, 24%), Big Data (22%), and Cloud Computing (18%) are the most frequently applied, forming the essential infrastructure for smart city initiatives, while Artificial Intelligence (13%) and Blockchain (7%) represent emerging strategic enablers. Furthermore, bibliometric analysis reveals strong emphasis on data security, privacy, governance, and efficient urban monitoring, addressing the complexities associated with extensive technological deployment. This systematic review consolidates key insights into existing development frameworks and technologies, providing policymakers, urban planners, and researchers with critical knowledge to strategically guide future initiatives. Finally, the study underscores the necessity for more context-specific frameworks and critical assessments of technological implementations to overcome current limitations, enhance scalability, and achieve holistic, inclusive, and sustainable smart urban transformations.

Keywords: Smart Cities, Development Frameworks, Systematic Literature Review, Urban Innovation, Bibliometric Analysis.

1. Introduction

Smart city development has gained a pivotal role in the global urban transformation, driven by the growing demand for sustainability, energy efficiency and quality of life (Inac & Oztemel, 2022; Abusaada & Elshater, 2021). As cities seek to optimize their services through the integration of advanced technologies, such as the Internet of Things (IoT), artificial intelligence (AI) and Big Data, development frameworks emerge as a key building block for the structuring and governance of these urban environments (Ismagilova et al., 2022; Alshuwaikhat et al., 2022). These frameworks provide strategic and methodological guidelines for the implementation of smart solutions, ensuring their scalability and adaptability to different urban contexts (Jnr & Petersen, 2023; Bajdor & Starostka-Patyk, 2021).

Despite advances in research, significant gaps persist in the literature on the conceptualization and application of these frameworks. Most existing studies focus on specific cases or partial reviews, without offering a comprehensive and systematic view that analyzes global trends and challenges in the implementation of development frameworks (Khadidos et al., 2022; Kourtzanidis et al., 2021). Additionally, there is a lack of consensus on what elements should compose an optimal development framework and how its implementation can affect urban governance and citizen participation (Kumar et al., 2021 Christofi et al., 2021). This study seeks to close this gap through a systematic literature review (SLR), providing a detailed synthesis on current approaches and their impact on smart city planning, implementation and sustainability (Kuppa et al., 2022; Trindade et al., 2017).

From a theoretical perspective, this research is based on two models widely used in the analysis of technological adoption: the Diffusion of Innovations Theory (IDT) and the Technology-Organization-Environment (TOE) Framework (Hájek et al., 2022; Janssen et al., 2017). The IDT model provides insight into how technological innovations diffuse within an urban system and what factors affect their adoption, such as compatibility, relative advantage, and complexity (Kousis & Tjortjis, 2021; Rani & Kumar, 2022). For its part, the TOE model provides a structured framework to assess the technological, organizational and environmental determinants that influence the implementation of development frameworks in smart cities, considering aspects such as infrastructure, government regulation and the ability of organizations to adopt new technologies (Marimuthu et al., 2022; Myeong et al., 2022).

To achieve this purpose, a bibliometric analysis and systematic review of 18,309 scientific articles from indexed databases such as IEEE Xplore, Web of Science, Scopus, EBSCOhost, ProQuest and ScienceDirect was carried out. Applying PRISMA inclusion and exclusion criteria, 65 high-impact studies were selected and screened to identify publication patterns, technological trends, and predominant methodological approaches in research on development frameworks for smart cities (Szum, 2021; Yigitcanlar et al., 2018). The main objectives of this research are:

- Analyze the evolution and trends in the implementation of development frameworks in smart cities in recent years.
- Identify the most used technologies in the structuring of these frameworks, including IoT, AI, Blockchain and Big Data.
- Assess the impact of these frameworks on the scalability, sustainability and governance of smart cities.
- Determine the critical success factors and barriers in the adoption of development frameworks within different urban environments.

Finally, this study is organized as follows: Section II presents the theoretical background and context of the research; Section III describes the methodology applied; Section IV presents the results obtained through bibliometric analysis and systematic review; and Section V presents the conclusions and future lines of research.

2. Literature Review

2.1. Development framework

The concept of development framework has been widely discussed in academic literature and was defined as a set of principles, strategies and guidelines that guided the planning, implementation and evaluation of projects or initiatives (Ansari & Mehrotra, 2019). In the context of smart cities, this framework provided a methodological structure for the integration of innovative technologies and solutions in order to optimize urban management and improve the quality of life of citizens (Teixeira & Rezende, 2023).

Several approaches emerged to define its scope. Malkawi et al. (2022) emphasized the need for flexible and adaptive models that allowed for the integration of multiple technologies and the participation of key stakeholders such as governments, businesses, academics, and citizens. Others argued that these frameworks needed to focus on policy and regulatory aspects to ensure sustainability and equity in the implementation of urban technologies (Lim et al., 2018).

From a critical perspective, it was noted that many development frameworks prioritized technological solutions without adequately considering the social and environmental challenges of the digital transformation of cities (Eirinaki et al., 2018). Recent studies indicated that an overly technological approach generated inequalities in access to urban services, affecting certain sectors of the population (Ghaemi et al., 2018).

In this context, Mora et al. (2017) developed a bibliometric analysis on the evolution of research on smart cities. Their study evidenced conceptual fragmentation and lack of consensus in theoretical frameworks. However, their approach proved more descriptive than analytical, limiting themselves to mapping trends without offering an integrative synthesis or a clear normative model. Although it identified gaps in knowledge, it did not propose concrete solutions to overcome theoretical dispersion. Its contribution lay in the systematization of the debate, but it lacked a critical evaluation of the real impact of these approaches on urban policy formulation.

For their part, Chourabi et al. (2012) presented an integrative framework based on eight key dimensions. Their innovation resided in overcoming the purely technological vision, incorporating social, political and environmental factors. However, its lack of empirical validation and concrete metrics limited its applicability. Although it established a solid theoretical basis, it did not address how to prioritize dimensions according to specific contexts or how they interacted in practice. Its impact was conceptual but required further development for effective implementation in urban policies.

Appio et al. (2019) analyzed smart cities from the perspective of innovation ecosystems, highlighting technological advances and social challenges. Their interdisciplinary approach represented a key contribution, integrating innovation theory with urban management. However, its conceptual framework, although broad, lacked concrete case studies to validate its applicability in different contexts. Moreover, it did not delve into how urban actors were able to collaborate effectively in politically and economically constrained environments. Its impact was theoretical but required further connection to realistic implementation strategies.

A development framework for smart cities was essential for integrating technological innovation, sustainability and efficient governance. Its importance lay in providing structured guidelines that balanced technological advances with social and economic needs. Without a solid framework, smart city efforts became fragmented, limiting their impact. A well-defined approach facilitated collaboration among urban stakeholders, optimizing policy planning and implementation. The key was to combine theory and practice, ensuring adaptability to different contexts and promoting sustainable and inclusive solutions.

2.2. Smart Cities

Smart cities were defined in various ways in the literature, but in general terms, they represented urban environments that integrated information and communication technologies (ICT) with the purpose of improving operational efficiency, sustainability and the quality of life of citizens (Rani & Chauhdary, 2018). Their development not only responded to the need to optimize urban services, but also sought to transform the way people interacted with their environment, promoting a more dynamic and adaptive management of urban resources.

Over time, the smart city concept has generated extensive debates in academia and practice. Some studies defined it from a perspective focused on technological infrastructure and process automation, prioritizing efficiency in the provision of urban services through advanced monitoring and control systems (Fahmideh et al., 2021). Others, on the other hand, approached it from a more holistic approach, considering collaborative governance and citizen participation as fundamental elements for the evolution of these urban environments (García-Font, 2021). In this sense, Sabory et al. (2021) argued that a successful smart city model should not be limited only to the digitization and automation of services, but also needed to ensure social inclusion and accessibility, allowing all sectors of the population to benefit equitably from its advances.

In practical terms, the implementation of smart cities involved the convergence of multiple disciplines, including urban planning, environmental sustainability, software engineering and data science. The adoption of emerging technologies such as the Internet of Things (IoT), big data and artificial intelligence made it possible to optimize different aspects of urban life. These innovations were applied in mobility, facilitating smart transportation and efficient traffic management; in security, through video surveillance systems with predictive analytics; in energy, promoting smart grids to reduce consumption and improve distribution; and in waste management, implementing automated models for collection and recycling (Ghaemi et al., 2018).

Despite these advances, the literature also warned about the challenges and risks associated with the implementation of these technologies. It became evident that the massive use of urban data generated concerns regarding citizens' privacy by enabling surveillance practices that, in some cases, violated fundamental rights. Also, the reliance on private providers for critical infrastructure management introduced additional risks related to information security and technological sovereignty of cities (Lim et al., 2018). These issues highlighted the importance of developing regulatory frameworks that balance technological innovation with the protection of citizen rights, urban sustainability, and decision-making autonomy.

In this context, the present study analyzed the influence of development frameworks on the evolution of smart cities in recent years, identifying recurring patterns in their implementation, the main challenges they faced, and the opportunities that emerged for building more equitable, resilient, and sustainable urban environments (Sabory et al., 2021). The relationship between technology, governance and society was consolidated as a central axis in the configuration of these urban spaces, demanding more integrated strategies adaptable to social and economic changes.

3. Methodology

Following the methodological proposal (Kitchenham & Brereton, 2013), a systematic literature review (SLR) approach was used to ensure rigor, transparency and traceability in the process of collecting and analyzing scientific information. From this perspective, the topics relevant to the object of study were analyzed exhaustively, ensuring a broad and well-founded coverage of the existing evidence. The methodology adopted made it possible to address not only the main research questions, but also complementary questions that enriched the analysis. Likewise, reliable data sources were identified and selected, specific search procedures were defined, and inclusion and exclusion criteria were established to ensure the relevance and quality of the studies considered. In addition, rigorous mechanisms were implemented for the evaluation of the methodological quality of the selected papers, as well as for the structured extraction of key data. Finally, a careful synthesis of the results was performed, integrating the findings in a coherent and critical manner. A systematic review involved an orderly sequence of methodological steps-as shown in Figure 1-that had to be applied with precision to ensure the validity and consistency of the results obtained.

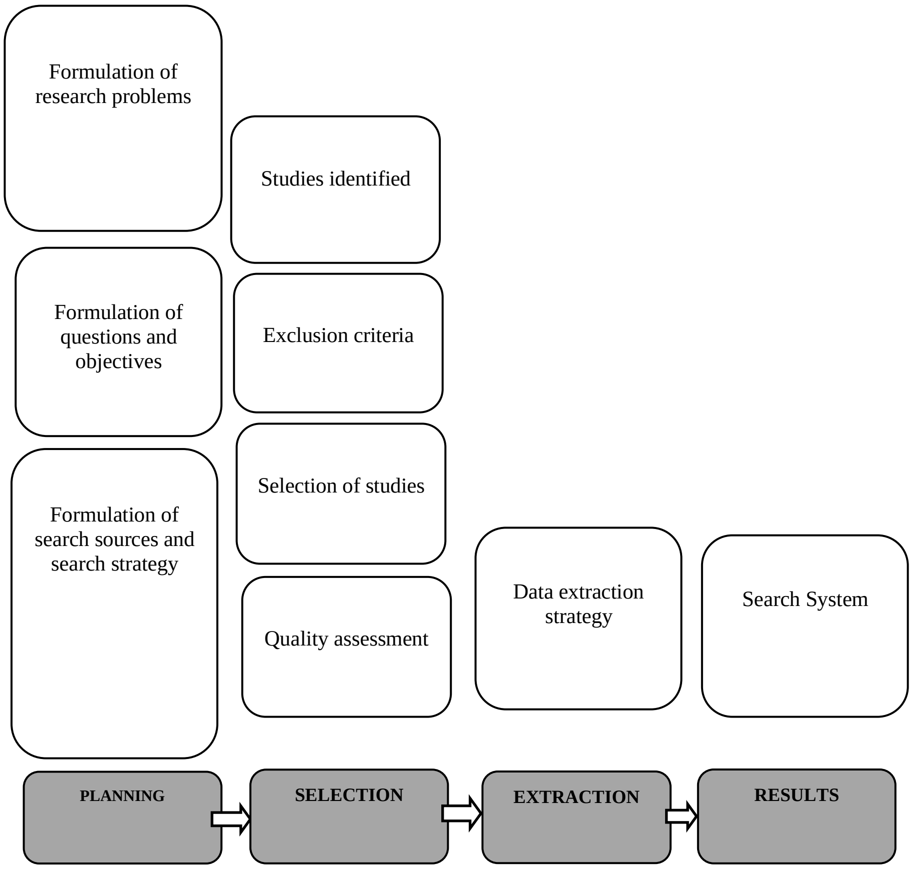


Fig 1: Stages of an SLR

3.1. Problems and Research Objectives

Given the scope and complexity of development within the framework of smart cities, it was essential to define precise search strategies that would allow the research to be properly structured. The formulation of research questions (RQs) played a key role in this process, as they guided the identification of gaps in knowledge and facilitated the establishment of concrete objectives. These questions not only delimited the focus of the study, but also ensured methodological coherence by guiding the selection of sources, data analysis and interpretation of results. In this sense, eight research questions were established, each with a specific objective, which are presented in Table 1. This framework of questions allowed for a systematic exploration of the challenges and opportunities of smart urban development, ensuring that the analysis conducted was not only comprehensive, but also relevant for strategy formulation and decision making in dynamic urban environments.

Table 1: Research Problems and Objectives

Research questions	Objectives
RQ1: At what quartile levels have journals published research on the impact of the development framework on smart cities?	Specify the quartile levels of journals where research on the impact of the development framework on smart cities has been published.
RQ2: What are the most prolific publications on the development framework and its impact on smart cities?	Identify the most productive publications on the development framework and its impact on smart cities.

RQ3: Which countries most frequently show co-occurrence in research on the development framework and its influence on smart cities?	Determine the countries that frequently show concurrence in research on the development framework and its influence on smart cities.
RQ4: Which research articles on the development framework and its impact on smart cities are characterized by high objectivity and moderate polarity in their conclusions?	Specify the articles with conclusions characterized by high objectivity and moderate polarity in research on the development framework and its impact on smart cities.
RQ5: What technologies are employed in a development framework for smart cities?	To detail the most commonly used technologies in smart city development frameworks.

To understand the impact of the development framework on smart cities, a structured analysis was conducted based on five research questions, each focused on a key aspect of the existing literature. First, the evaluation of the distribution of articles according to the quartile of journals indexed in Scopus and Web of Science (RQ1) identified a higher concentration of research in high impact publications, particularly in journals ranked Q1 and Q2. This finding evidenced that the academic discussion on development frameworks and smart cities took place in media of high scientific rigor, reflecting the relevance and growing interest in this field.

On the other hand, the analysis of the most prolific journals in research on development frameworks and smart cities (RQ2) facilitated the identification of the main spaces for the dissemination of knowledge in this field. This result allowed researchers to orient their search towards specialized sources and establish key references within the field of study. Regarding research co-occurrence between countries (RQ3), a bibliometric analysis was applied using VOSviewer, establishing a minimum threshold of keyword co-occurrence. For the visualization of international collaboration patterns, the Louvain clustering method was implemented, allowing the detection of regions with higher activity in scientific production on smart cities and development frameworks. This approach revealed cooperation dynamics between countries, pointing out those that led the research agenda and those with less presence in the literature.

The evaluation of the objectivity and polarity of the publications (RQ4) was carried out using a quantitative approach based on the argumentative classification of the studies. Specific criteria were defined to analyze the level of moderation in the conclusions, making it possible to visualize trends by means of distribution graphs. This was key to identifying publications with more balanced approaches and those with interpretative biases, contributing to a better appreciation of the diversity of perspectives in the field. Finally, in the analysis of technologies applied to smart city development frameworks (RQ5), key tools such as the Internet of Things (IoT), Big Data and Artificial Intelligence were identified. These technologies emerged as fundamental pillars in the implementation of smart city strategies, being applied in areas such as urban monitoring, data analysis and service automation. The relevance of these technologies highlighted the importance of their integration with flexible and sustainable development frameworks to maximize their positive impact on smart city planning and management. This analysis provided a comprehensive overview of the current state of the literature on smart city development frameworks, identifying trends, challenges and opportunities that will guide future research in the area.

3.2. Information sources and search strategies

To ensure exhaustive coverage of the relevant literature, bibliographic databases of high impact and recognition in the academic field were selected. These included IEEE Xplore, Web of Science, Scopus, EBSCOhost, ProQuest and ScienceDirect, ensuring access to quality and scientifically rigorous research. The search strategy was designed with a structured approach, combining specific key terms to optimize the retrieval of relevant information. Precise search criteria were established, considering keywords and Boolean operators, in order to refine the results and avoid the inclusion of irrelevant publications. Table 2 presents a detailed breakdown of the keywords used in this process.

This methodological approach made it possible to obtain a representative corpus of literature, ensuring the validity and reliability of the analysis. In addition, the combination of multiple databases enabled a broader and more balanced view of the state of the art in the study of development frameworks and smart cities.

Table 2: Search descriptors and their synonyms

Descriptor	Synonyms
Development framework	("framework" OR "reference framework" OR "development platform" OR "frame of reference" OR "job description" OR "development architecture" OR "development infrastructure" OR "development structure" OR "development scheme" OR "implementation model" OR "urban planning framework" OR "urban development strategy" OR "policy framework")
Smart cities	("smart cities" OR "digital cities" OR "technological cities" OR "sustainable cities" OR "smart city" OR "digital city" OR "technological city" OR "sustainable city" OR "intelligent urban systems" OR "connected cities" OR "urban innovation" OR "resilient cities" OR "data-driven cities" OR "urban intelligence")

Strategic key terms were used in the information sources and in the formulation of search equations to optimize the retrieval of relevant data. This approach ensured a more precise and effective search, covering a wider spectrum of studies and publications relevant to the research object. In addition, Boolean operators and synonym combinations were applied to improve inclusiveness and minimize the omission of significant papers. Table 3 presents in detail the terms used and their application in the search strategies.

Table 3: Sources of information and search equations.

Source	Search Equation
IEEE Xplore	(("Document Title": "framework" OR "Document Title": "reference framework" OR "Document Title": "development platform" OR "Document Title": "frame of reference" OR "Document Title": "job description" OR "Document Title": "development architecture" OR "Document Title": "development infrastructure" OR "Document Title": "development structure" OR "Document Title": "development scheme") AND ("Document Title": "smart cities" OR "Document Title": "digital cities" OR "Document Title": "technological cities" OR "Document Title": "sustainable cities" OR "Document Title": "smart city" OR "Document Title": "digital city" OR "Document Title": "technological city" OR "Document Title": "sustainable city")) OR (("Abstract": "framework" OR "Abstract": "reference framework" OR "Abstract": "development platform" OR "Abstract": "frame of reference" OR "Abstract": "job description" OR "Abstract": "development architecture" OR "Abstract": "development infrastructure" OR "Abstract": "development structure" OR "Abstract": "development scheme")) AND (("Abstract": "smart cities" OR "Abstract": "digital cities" OR "Abstract": "technological cities" OR "Abstract": "sustainable cities" OR "Abstract": "smart city" OR "Abstract": "digital city" OR "Abstract": "technological city" OR "Abstract": "sustainable city"))
Web of Science	((TI=(("framework" OR "reference framework" OR "development platform" OR "frame of reference" OR "job description" OR "development architecture" OR "development infrastructure" OR "development structure" OR "development scheme") AND ("smart cities" OR "digital cities" OR "technological cities" OR "sustainable cities" OR "smart city" OR "digital city" OR "technological city" OR "sustainable city"))) OR AB=(("framework" OR "reference framework" OR "development platform" OR "frame of reference" OR "job description" OR "development architecture" OR "development infrastructure" OR "development structure" OR "development scheme") AND ("smart cities" OR "digital cities" OR "technological cities" OR "sustainable cities" OR "smart city" OR "digital city" OR "technological city" OR "sustainable city"))) OR AK=(("framework" OR "reference framework" OR "development platform" OR "frame of reference" OR "job description" OR "development

Source	Search Equation
	architecture" OR "development infrastructure" OR "development structure" OR "development scheme") AND ("smart cities" OR "digital cities" OR "technological cities" OR "sustainable cities" OR "smart city" OR "digital city" OR "technological city" OR "sustainable city"))
Scopus	TITLE-ABS-KEY (("framework" OR "reference framework" OR "development platform" OR "frame of reference" OR "job description" OR "development architecture" OR "development infrastructure" OR "development structure" OR "development scheme") AND ("smart cities" OR "digital cities" OR "technological cities" OR "sustainable cities" OR "smart city" OR "digital city" OR "technological city" OR "sustainable city"))
EBSCOhost	TI (("framework" OR "reference framework" OR "development platform" OR "frame of reference" OR "job description" OR "development architecture" OR "development infrastructure" OR "development structure" OR "development scheme") AND ("smart cities" OR "digital cities" OR "technological cities" OR "sustainable cities" OR "smart city" OR "digital city" OR "technological city" OR "sustainable city")) OR AB (("framework" OR "reference framework" OR "development platform" OR "frame of reference" OR "job description" OR "development architecture" OR "development infrastructure" OR "development structure" OR "development scheme") AND ("smart cities" OR "digital cities" OR "technological cities" OR "sustainable cities" OR "smart city" OR "digital city" OR "technological city" OR "sustainable city")) OR SU (("framework" OR "reference framework" OR "development platform" OR "frame of reference" OR "job description" OR "development architecture" OR "development infrastructure" OR "development structure" OR "development scheme") AND ("smart cities" OR "digital cities" OR "technological cities" OR "sustainable cities" OR "smart city" OR "digital city" OR "technological city" OR "sustainable city"))
ProQuest	title(("framework" OR "reference framework" OR "development platform" OR "frame of reference" OR "job description" OR "development architecture" OR "development infrastructure" OR "development structure" OR "development scheme") AND ("smart cities" OR "digital cities" OR "technological cities" OR "sustainable cities" OR "smart city" OR "digital city" OR "technological city" OR "sustainable city")) OR abstract(("framework" OR "reference framework" OR "development platform" OR "frame of reference" OR "job description" OR "development architecture" OR "development infrastructure" OR "development structure" OR "development scheme") AND ("smart cities" OR "digital cities" OR "technological cities" OR "sustainable cities" OR "smart city" OR "digital city" OR "technological city" OR "sustainable city"))
ScienceDirect	Title, abstract, keywords: ("framework" OR "reference framework" OR "development platform" OR "frame of reference" OR "development architecture") AND ("smart city" OR "digital city" OR "smart cities" OR "digital cities").

3.3. Identified Studies

This section presents the quantitative distribution of the relevant documents identified during the initial phase of scientific literature collection. This methodological stage is crucial to dimension the scope of the review, as it consolidates a representative corpus of studies extracted from high-impact academic databases. Figure 2 illustrates this distribution, showing the diversity and strength of the sources consulted.

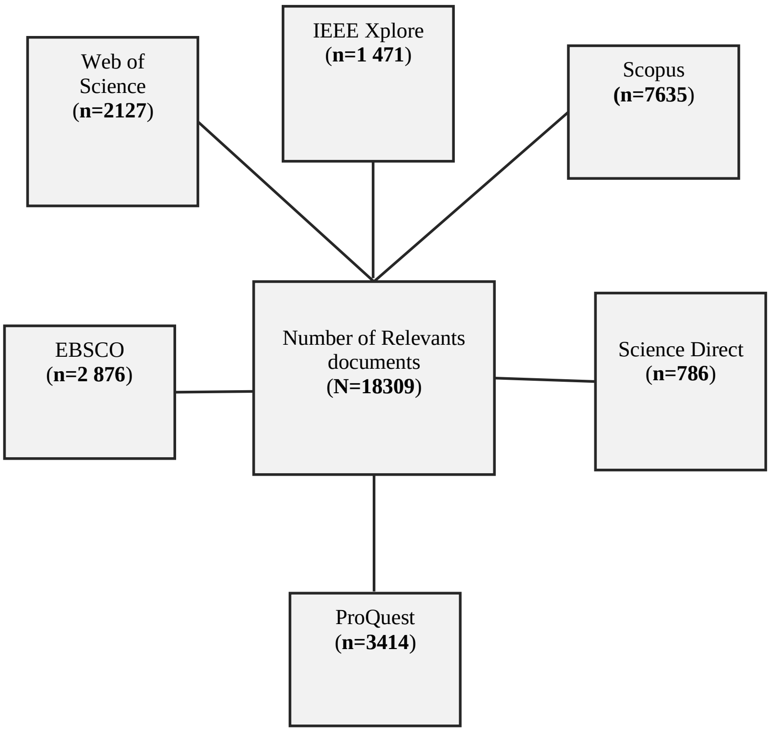


Fig 2: Relevant Papers Results

Figure 2 presents in a structured manner the total number of relevant documents identified in the initial stage of the systematic literature review (SLR) process, specifying the origin of the publications from six highly relevant scientific databases: IEEE Xplore, Web of Science, Scopus, ScienceDirect, ProQuest and EBSCOhost. In total, 18,309 records were collected to form the preliminary documentary corpus before being subjected to the inclusion and exclusion criteria established under the methodological guidelines of the PRISMA protocol. This initial volume constitutes a robust basis for the rigorous filtering and subsequent bibliometric and thematic analysis of the phenomenon under investigation.

The quantitative breakdown shows the specific weight of each database in the scientific literature related to development frameworks for smart cities. Scopus leads with 7,635 articles (41.7%), which reinforces its position as a multidisciplinary platform of reference in technological, urban and social studies. It is followed by ProQuest with 3,414 records (18.6%) and EBSCOhost with 2,876 documents (15.7%), both with high content in areas such as strategic planning, public policy and urban development. Web of Science, with 2,127 articles (11.6%), provides methodological rigor given its high selectivity in impact publications. IEEE Xplore, with 1,471 documents (8%), mainly represents contributions oriented to technological solutions from engineering. Finally, ScienceDirect, with 786 publications (4.3%), incorporates relevant literature from applied scientific approaches and urban sustainability.

Beyond its descriptive value, this graphic representation allows validation of the breadth, diversity and depth of the methodological design employed, by guaranteeing broad and representative bibliographic coverage. The combination of multidisciplinary sources minimizes thematic and disciplinary biases, providing a comprehensive view of the analyzed phenomenon. This preliminary phase not only justifies the relevance of the systematic approach adopted, but also constitutes the empirical foundation that supports the subsequent critical analysis, strengthening the academic rigor and legitimacy of the findings obtained in this research.

3.4. Identified Studies

At this stage, rigorous exclusion criteria were applied to ensure the quality, relevance, and academic integrity of the literature reviewed. The following ten criteria were used to assess the eligibility of the selected studies:

- EC1: Papers are more than seven years old.
- EC2: Papers are not written in English.
- EC3: Papers are not systematic reviews.
- EC4: Papers were not published in peer-reviewed journals or conferences.
- EC5: Full-text access to the paper is unavailable.
- EC6: Abstracts lack sufficient relevance to the research topic.
- EC7: Conferences or journals are not indexed in Scopus or Web of Science.
- EC8: Papers are brief (less than ten pages in length).
- EC9: Titles and keywords are misaligned with the scope of the study.
- EC10: Duplicate publications.

The rigorous application of the exclusion criteria allowed for a highly systematic filtering process, which not only eliminated studies with structural or methodological weaknesses, but also ensured the direct relevance of each publication with respect to the object of study. By discarding documents with limitations in accessibility, language, scientific rigor or academic visibility, a robust bibliographic set was consolidated, aligned with international standards of systematic review. This procedure was not limited to a mechanical exclusion exercise but functioned as a critical phase to strengthen the internal consistency of the study. By ensuring that each article included met replicable and objective criteria, bias was minimized, and thematic representativeness was maximized, which favors the integrity of the analysis and the comparability of the findings. Consequently, the final corpus reflects a solid synthesis of the most relevant literature, providing a reliable empirical basis from which to structure the subsequent bibliometric and critical analysis.

3.5. Study Selection

The initial search, based on a structured strategy of keywords related to smart city development frameworks, yielded a total of 18,309 documents from indexed academic databases. Subsequently, all the previously defined exclusion criteria (EC) were rigorously applied in order to guarantee the quality, thematic relevance and methodological validity of the documentary corpus. As a result of this purification process, 65 studies were selected that met the established standards, which constitute the final set of research considered for the analysis, as detailed in Figure 3.

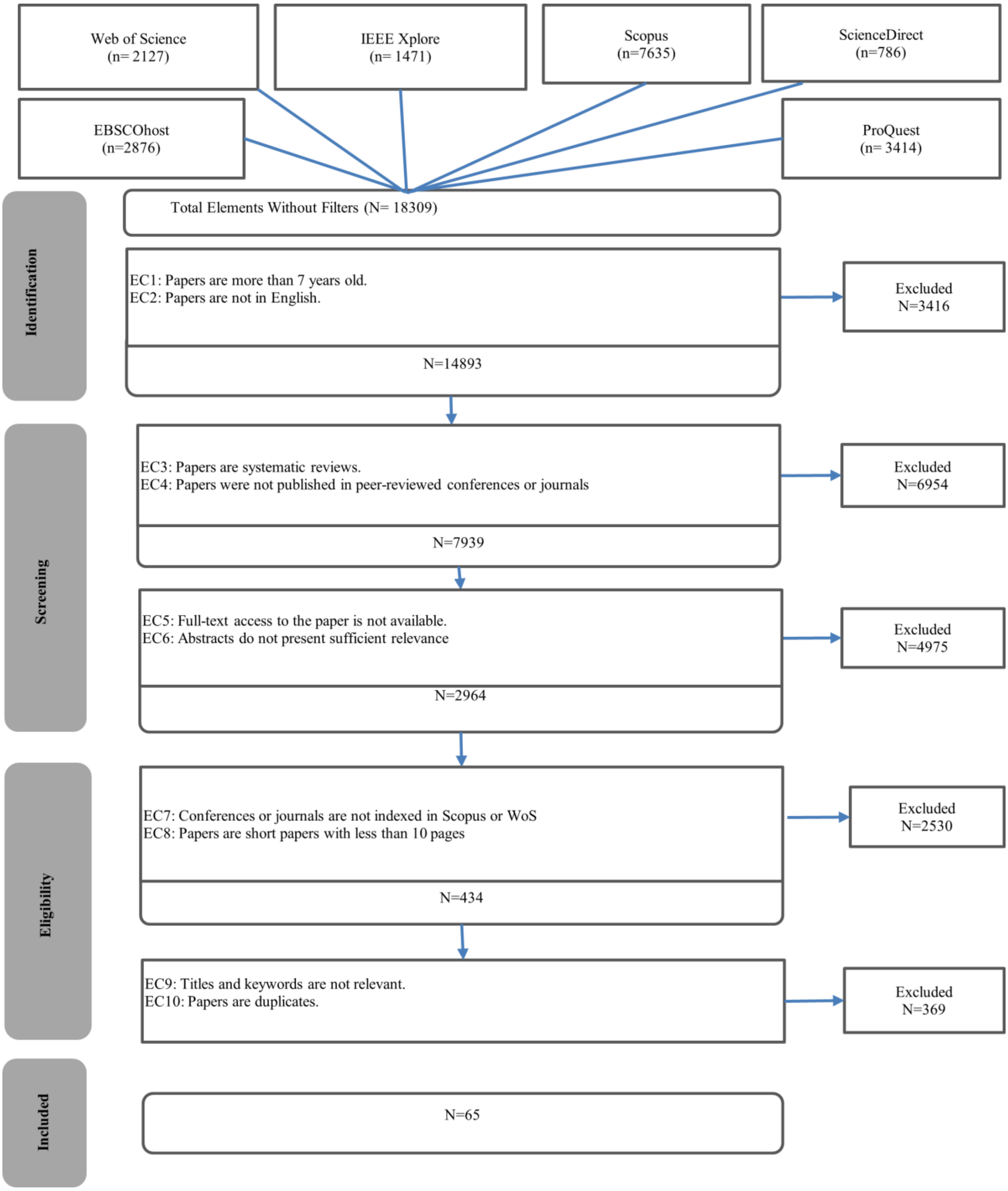


Fig 3: PRISMA Flow Diagram

The PRISMA diagram shows the rigorousness of the purification process, reflecting that only a minimal fraction of the 18,309 initial documents (barely 0.35%) met the established quality criteria. This drastic reduction highlights the thematic dispersion and scarce specificity in the literature, which justifies the need for this systematic review and its contribution to the theoretical strengthening of the field of study.

3.6. Quality Assessment

The rigorous evaluation of the quality of the included studies was a decisive phase in the systematic review process, aimed at guaranteeing the reliability, methodological consistency and academic relevance of the final corpus. This stage was not limited to verifying the thematic relevance but involved a structured examination of the scientific integrity of each article, considering both its content and expository clarity and its ability to respond to the study objectives. To this end, previously defined quality criteria were applied to filter out only those papers with high levels of internal cohesion, analytical depth and empirical or conceptual contribution to the field of smart city development frameworks. The quality criteria used were as follows:

- **QA1:** Does the document present an adequate organization?
- **QA2:** Are the research objectives clearly identified?
- **QA3:** Does the paper provide sufficient contextual and background information?
- **QA4:** Is the specific topic area addressed clearly delimited?
- **QA5:** Does the paper include practical experimentation or empirical validation?
- **QA6:** Is the data set used clearly identified and described?
- **QA7:** Are the methods used to analyze the results appropriate and well justified?

The evaluation process not only made it possible to validate the formal quality of the documents, but also to identify the scientific maturity of the studies and their potential for generalization in different contexts. All of the selected articles passed this stage satisfactorily, which is evidence of a solid base of reliable references on which the analysis was built. This exhaustive validation strengthened the credibility of the findings, providing consistency to the interpretative framework and ensuring that the conclusions derived were based on rigorously contrasted evidence. In short, this stage not only filtered the most appropriate documentation, but also raised the analytical standard of the study, consolidating its academic contribution to the contemporary debate on smart cities.

3.7. Data Extraction Strategy

The purpose of the data extraction strategy implemented in this research was to collect relevant and structured information that would allow a precise answer to the research questions posed. To this end, a systematic data collection protocol was designed for each of the selected articles, ensuring consistency in the process and homogeneity in the treatment of the information. The elements extracted from each document included: article identifier (ID), title, URL, ISSN, source of publication, year, country, number of pages, language, type of document, name of the journal, authors, group of actors involved, number of citations, summary (abstract), keywords and sample size. This variety of variables made it possible to construct a multifactorial analysis matrix, from which it was possible to identify patterns, correlations and gaps within the body of documents.

It is important to note that not all papers provided complete data for each of these variables, nor did they contribute equally to answering all of the research questions. Nevertheless, the wealth of information and diversity of approaches present in the papers analyzed facilitated a broad and robust exploration of the state of the art around development frameworks for smart cities. This extraction phase was not only instrumental for the subsequent quantitative and qualitative analysis, but also allowed us to validate the thematic coherence and empirical relevance of each publication within the selected corpus.

3.8. Synthesis of Findings

Once the information was extracted from the selected studies, the data were organized and analyzed with the aim of answering the previously defined research questions. This process involved the elaboration of comparative tables and graphical representations that facilitated the visualization of the results and made it possible to identify common patterns, recurrent approaches and persistent gaps in the academic literature. Subsequently, the findings were contrasted with previous studies to verify their consistency, detect emerging trends and enrich the interpretative analysis from a critical perspective. This comparison allowed not only to validate the results obtained, but also to contextualize them within the international research landscape.

Overall, this synthesis revealed significant research trends developed over the last seven years, highlighting the evolution of the development frameworks applied to smart cities, the most widely used technologies, the most active countries and the thematic lines with the greatest projection. This set of findings constitutes a relevant contribution to the theoretical and practical strengthening of the field.

4. Results

This results section summarizes the findings obtained from the bibliometric analysis and the systematic review of literature related to smart city development frameworks. It addresses key aspects such as the evolution of scientific production in the last seven years, the distribution of studies according to impact quartiles, the countries with the highest research participation, the technologies most used in these frameworks, and the patterns of thematic co-occurrence. Critical dimensions such as the objectivity and polarity of the conclusions, as well as the methodological alignment of the studies reviewed, are also analyzed. All the results are presented by means of graphs, tables and interpretative descriptions that allow a structured and comparative reading. This section not only seeks to present quantitative data, but also to provide an analytical understanding of the current landscape around smart cities, identifying consolidated trends, theoretical gaps and opportunities for future research.

4.1. General Description of the Studies

In recent years, the concept of smart cities has progressively captured the attention of researchers, academics and professionals from multiple disciplines. This interest was due to the incorporation of advanced technologies that offered new possibilities for improving the quality of life of citizens, optimizing public services and promoting urban sustainability. Against this backdrop, an exhaustive analysis of scientific publications was carried out with the purpose of understanding the scope, evolution and research maturity of this emerging field. Over the last seven years, numerous studies focused on different dimensions of smart cities were carried out, which allowed us to observe a growing consolidation of the topic in the international academic agenda. This analysis identified the predominant trends in the literature and highlighted the most recurrent approaches within the scientific communities. Likewise, the areas of greatest research concentration were distinguished, revealing specific thematic interests linked to urban governance, the application of disruptive technologies, and the design of development frameworks aimed at the digital transformation of urban environments.

Figure 4 showed the annual evolution of the number of publications in this field during the period analyzed, which made it possible to visualize not only the progressive increase in scientific production, but also the growing institutionalization of the smart city concept as a transversal object of study. This bibliometric behavior provided a solid basis for understanding the positioning of the topic in the current literature, as well as for detecting opportunities for further research.

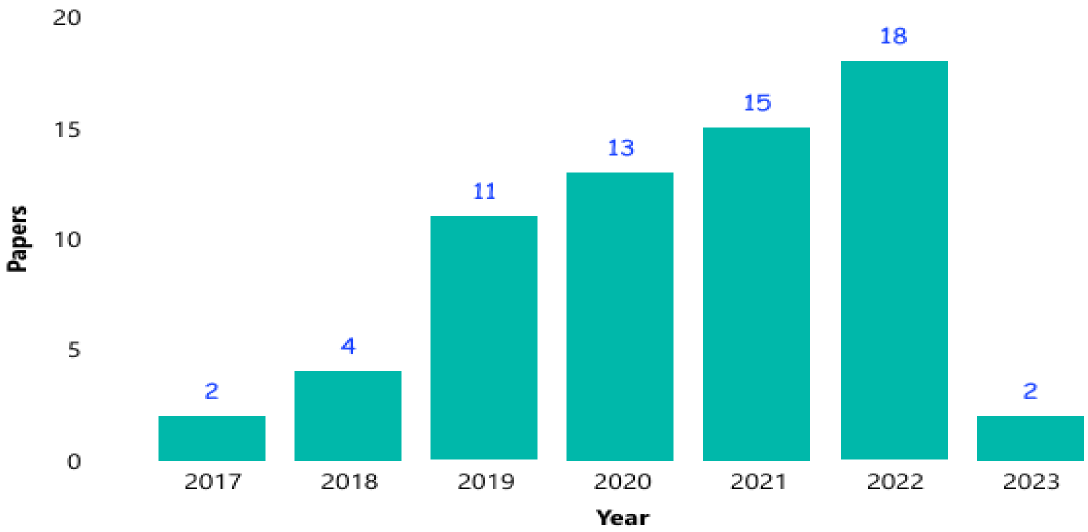


Fig 4: Number of Papers per Year.

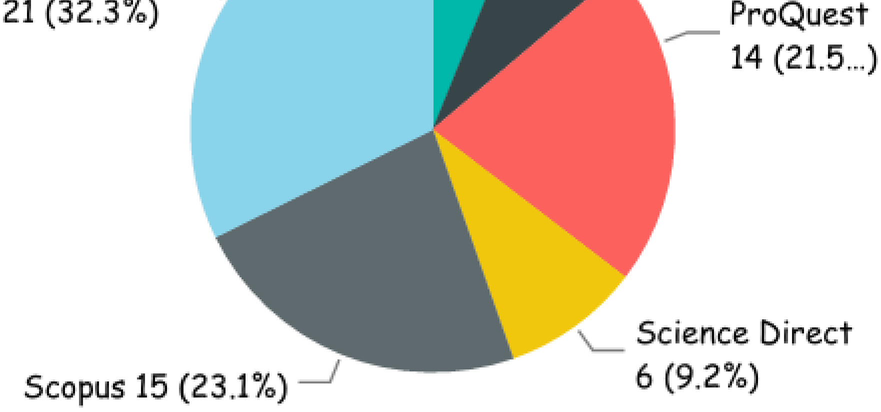
Figure 4 shows the evolution of scientific production related to smart cities over the last seven years, showing a sustained growth until reaching its peak in 2022, with a total of 18 publications. This increase not only reflects greater academic interest, but also the consolidation of the topic as a priority research area in various disciplines. The marked upward trajectory to 2022 can be attributed to the growing need to address urban challenges through technological solutions, which has prompted governments, institutions and companies to collaborate with the scientific community to design more efficient and sustainable development frameworks. This context has boosted the publication of studies that seek to generate knowledge applicable to complex urban environments.

However, 2023 shows a significant decrease with 2 publications, which is predictable considering that the year has not ended. This result does not necessarily imply a reduction in interest in smart cities but could be due to factors such as review and publication times in high-impact journals, where editorial processes usually take several months. In addition, it is possible that the prioritization of longitudinal studies or the search for greater methodological contributions has slowed production compared to previous years. In this sense, monitoring the end of the year will allow us to obtain a more accurate view of the current trend and its future projection.

It should be noted that the identification of 2022 as the most productive year is not uniform in the literature. Studies such as (Alshuwaikhat et al., 2022) identified 2021 as the year with the highest production, while (Marimuthu et al., 2022) also recognized 2021 as a critical point in research on the subject. On the other hand, (Rani & Kumar, 2022) highlighted 2020 as the most relevant period. These discrepancies highlight the influence of methodological factors in determining the most productive years. First, differences in the time ranges used by each study may condition the perception of academic productivity. Second, the selection of databases and bibliographic sources directly influences the results, since some platforms include a greater number of specific publications on smart cities. Finally, the inclusion and exclusion criteria applied by each author have a significant impact on the number of studies considered relevant, limiting or expanding the corpus of analysis.

Despite these divergences, the general growth trend up to 2022 reaffirms the academic relevance of the field and its consolidation as an interdisciplinary area of study. The evolution of scientific production not only reflects the dynamism of research on smart cities, but also the identification of new urban issues that require innovative solutions. In addition, the increase in publications may be related to the financial and political support for urban innovation projects, which encourages scientific production in collaboration with public and private sectors. This expansion also raises the need to evaluate the real impact of the studies on the formulation of public policies and the effective transformation of cities.

Finally, understanding the temporal distribution of scientific publications is key to identifying



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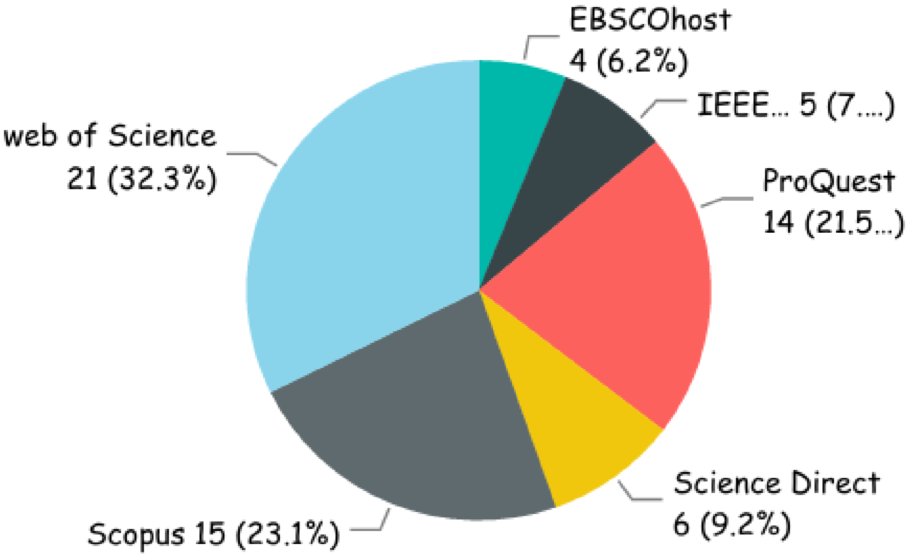

Fig 5: Number of Papers by Source.

Figure 5 shows the distribution of the selected publications according to their bibliographic source, highlighting that Web of Science and Scopus represent the main databases consulted, with a combined contribution of 55.4% of the articles included. This concentration reflects not only the importance of these platforms as high impact repositories in scientific research, but also their position as key references for studies related to the development of smart cities. The prevalence of Web of Science (32.3%) suggests that researchers prioritize sources with rigorous peer review processes and recognized citation metrics, which increases the credibility and relevance of published articles.

On the other hand, Scopus (23.1%) also plays a significant role, especially for its multidisciplinary coverage and its capacity to index emerging research in technological and social fields. Its broad representation indicates that studies on smart cities require an interdisciplinary approach, combining knowledge from engineering, social sciences, and urban management. This duality of sources strengthens the methodological rigor of research by integrating diverse perspectives and complementing gaps that a single database might present (Zielinska-Dabkowska, 2022).

The presence of ProQuest (21.5%) is evidence of interest in studies from conferences and gray literature, which provides a more applied and contextualized approach. This can be especially useful in topics where practical solutions and case studies predominate over traditional theoretical frameworks. However, the lower participation of databases such as ScienceDirect (9.2%), IEEE Xplore (7.7%) and EBSCOhost (6.2%) suggests an underrepresentation of research focused on specific technology applications or studies in applied science. This raises an opportunity for future reviews to broaden the search spectrum and consider additional sources to obtain a more comprehensive view of the field (Xenou et al., 2022).

A critical aspect to highlight is the possible publication bias associated with reliance on databases with restrictive indexing criteria. Although prioritizing Web of Science and Scopus guarantees quality and academic rigor, it can also exclude valuable contributions from authors from regions or institutions with less access to these platforms. This limits the geographic and methodological diversity of the findings, which in turn could impact the applicability of the results in less studied urban contexts (Rani & Kumar, 2022).

Finally, the use of duplicate exclusion criteria when selecting articles from multiple sources ensures the elimination of redundancies and optimizes the representativeness of the results. This process also reflects the importance of a structured search strategy and transparent methodological decisions to minimize bias and ensure greater analytical robustness in systematic review studies; while the prevalence of Web of Science and Scopus validates the reliability and relevance of the included publications, future research could benefit from a broader integration of alternative databases to foster a more equitable and representative global view in the study of smart cities. In addition, ongoing evaluation of selection methodologies will help strengthen the interpretation of results and enrich perspectives in the field.

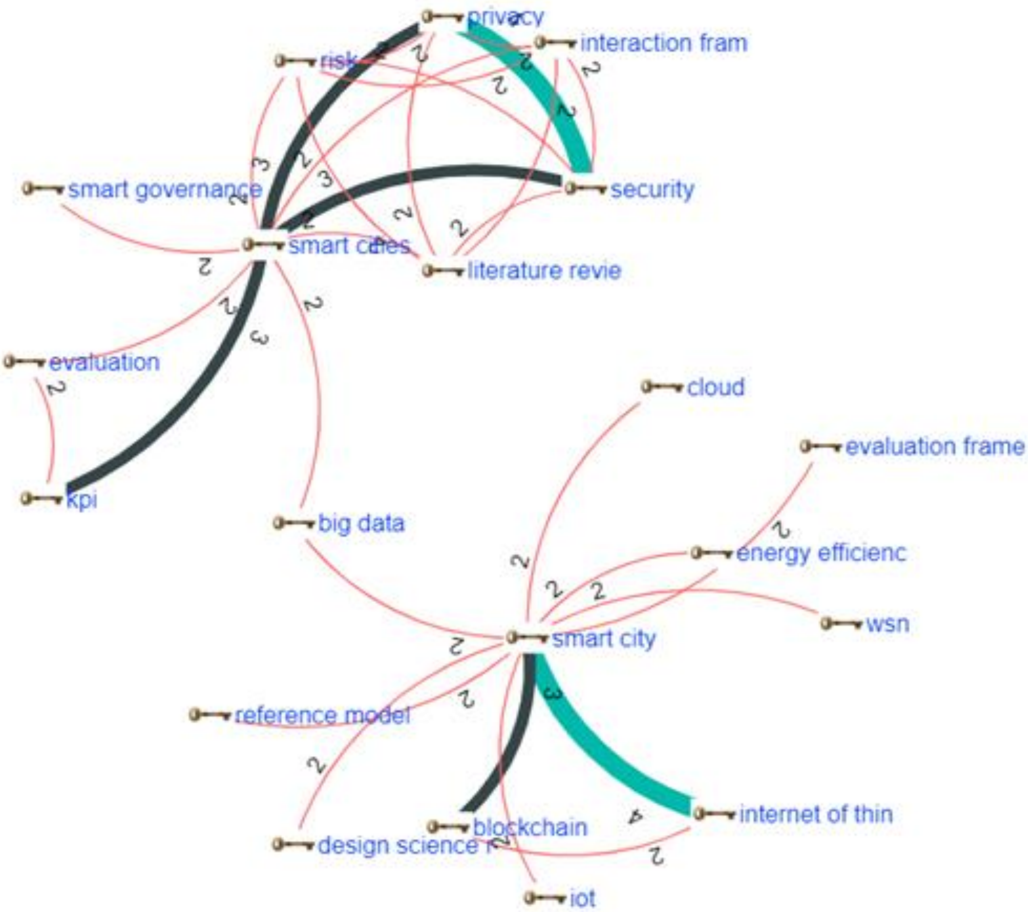

Fig 6: Concurrent Keyword

Figure 6 shows the co-occurrence of keywords in studies on smart cities, highlighting terms such as “Internet of Things” (IoT), “Smart City”, “Security” and “Blockchain”. These keywords reflect the predominant focus on the application of advanced technologies to address urban challenges, with a particular emphasis on security, privacy and energy efficiency. The high frequency of terms related to security and privacy indicates a growing concern for data protection and information management in smart environments. Also, the prominent presence of IoT and Blockchain suggests an interest in decentralized and connected solutions that enhance urban governance and improve decision making.

In addition, terms such as “Evaluation Framework” and “KPI” point to the need to measure and evaluate the performance of smart city initiatives, ensuring their sustainability and effectiveness. The emergence of keywords such as “Smart Governance” and “Design Science” reflects a holistic approach that combines technological advances with management frameworks and public policies. In terms of implications, this co-occurrence analysis reveals not only key areas of current research, but also opportunities to address existing gaps. For example, the limited presence of terms associated with citizen participation or urban equity evidences the need to explore inclusive approaches to smart city design. In addition, strengthening research on reference models and evaluation frameworks will allow the development of solutions more adapted to specific contexts (Sivrikaya et al., 2019).

In summary, Figure 6 not only identifies the main areas of focus in the existing literature, but also provides a solid foundation for future research, promoting safer, more efficient urban development focused on the needs of society.

4.2. Answers to the research questions

This section provides detailed and analytical responses to the five research questions formulated in this investigation. Each answer is supported by the findings from the systematic literature review, offering a critical interpretation of the results. Through a comprehensive analysis, this study identifies significant trends, challenges, and opportunities in the development frameworks for smart cities. The insights presented aim to contribute to the existing body of knowledge, guide policymakers, and inform future research directions in the field of smart urban development.

RQ1: At what quartile levels have the journals published research on the impact of the development framework on smart cities?

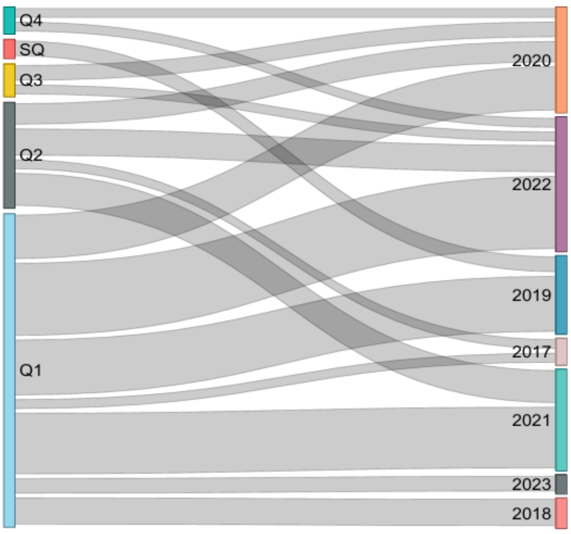

Fig 7: Concurrent Keyword

Figure 7 presents a Sankey plot illustrating the distribution of articles on the impact of the Development Framework on smart cities, categorized by quartile and year of publication. This analysis reveals a predominance of publications in Q1 and Q2 quartile journals, suggesting that research in this field maintains a focus on high quality and academic relevance. The notable concentration of articles in these quartiles reflects the consolidation of the topic in prestigious journals, validating its impact on the international scientific agenda.

During 2019 and 2020, a significant increase in Q2 publications was observed, probably driven by the need for practical studies and emerging technological applications. In contrast, the year 2022 was notable for an increase in Q1 publications, indicating a greater acceptance of research with methodological rigor and substantial theoretical contributions. This trend reflects not only a growth in the number of studies, but also a strengthening in the quality and academic recognition of the subject.

The low representation of articles in the Q3 and Q4 quartiles suggests a lower diffusion in lower impact journals, which could limit the transfer of knowledge to emerging or interdisciplinary academic communities. This concentration in high-impact journals, while validating the quality of the studies, also raises questions about the accessibility of the knowledge produced. To mitigate this gap, future research could explore strategies to diversify publication channels and promote the dissemination of relevant findings in lower quartile journals, particularly those with a regional or specialized focus.

Also, the absence of studies that critically address the relationship between quartile levels and scientific output in the field of smart cities represents an unexplored research opportunity. This pioneering analysis contributes to filling that gap, providing a valuable perspective for assessing the evolution and consolidation of the field. Furthermore, the identification of patterns in the choice of high-impact journals can guide future researchers to prioritize publications in Q1 and Q2 journals to maximize visibility and recognition of their contributions.

In terms of implications, this predominance of articles in higher impact journals reflects a competition for academic recognition and access to influential scientific audiences. However, it also invites reflection on the need to balance the quest for prestige with the responsibility to make knowledge more accessible. Promoting interdisciplinary collaborations, publishing in a wider diversity of journals, and fostering practical application studies can contribute to a more inclusive and equitable research ecosystem in the field of smart cities (Rani & Chauhdary, 2018).

RQ2: Which are the most prolific publications on the development framework and its impact on smart cities?

Table 4: Number of papers by Publication

Publication names	2017	2018	2019	2020	2021	2022	2023	Total
Sustainability	0	0	1	2	3	4	0	10
Sensors	1	1	1	0	2	1	0	6
IEEE Access	0	0	2	2	0	1	0	5
Smart Cities	0	0	1	0	2	1	1	5
Applied Sciences	0	0	0	0	2	1	0	3
Energies	0	1	1	0	0	0	0	2
Sustainable Cities and Society	0	1	0	0	0	0	0	1
Australasian Journal on Information Systems	0	0	0	1	0	0	0	1
Buildings	0	0	0	0	0	1	0	1
Bulletin of Geography Socio-economic Series	0	0	0	0	0	1	0	1
Cities	0	1	0	0	0	0	0	1
Complex and Intelligent Systems	0	0	0	0	1	0	0	1
Computers and Security	0	0	0	1	0	0	0	1
Computers, Environment, and Urban Systems	0	1	0	0	0	0	0	1
Deanship of Scientific Research	0	0	0	0	0	1	0	1
European Journal of Futures Research	0	0	0	1	0	0	0	1
Future Generation Computer System	0	0	1	0	0	0	0	1
TOTAL	2	4	11	13	15	18	2	65

Table 4, provides a detailed overview of the number of articles published by each journal between 2017 and 2023, allowing to identify the most prolific publications in research on development frameworks and their impact on smart cities. This analysis not only evidences the main sources of knowledge in this field, but also the editorial trends and the evolution of academic interest over time.

Sustainability stands out as the journal with the largest number of publications, consolidating its position as a benchmark in the intersection between sustainable urban development and smart cities. Its interdisciplinary approach and commitment to applied research explain its leadership in terms of scientific productivity. It is followed by Sensors and IEEE Access, both journals with a strong technological orientation. Sensors specializes in research related to sensor systems and monitoring technologies, fundamental aspects for the implementation and management of smart urban infrastructures. IEEE Access is a multidisciplinary journal recognized for its focus on technological innovations, covering key areas such as artificial intelligence, robotics, communications and data analysis.

However, it is relevant to contrast these findings with previous studies. For example, Bajdor and Starostka (Moustaka et al., 2021) identified Smart Cities as the most productive journal in terms of publications related to smart city development. In contrast, this study ranks it in third place, reflecting a possible diversification in publication sources or increased competitiveness in academia. Likewise, Kousis and Tjortjis (Naqvi et al., 2020; Zhao & Karypis, 2002) pointed out that IEEE Access and Sensors led the scientific production in this field, which coincides with the results obtained in this research and reinforces their relevance as main platforms for the dissemination of technological advances applied to urban environments.

The marked presence of journals with technological and sustainability approaches suggests that current research prioritizes both the development of technical solutions and the evaluation of their environmental and social impact. This balance between technology and sustainability reflects the growing need to address the complex challenges facing cities in their transition to smart and resilient models (Oh, 2020).

However, the decrease in the number of publications during 2023 may indicate a change in research priorities or a possible saturation of the subject in the main specialized journals. This trend could also be due to external factors, such as long lead times in editorial processes or the search for new emerging research areas. To mitigate these effects, researchers could explore publications in specialized journals of lower impact or in complementary areas, thus broadening the dissemination of knowledge and encouraging greater diversity in the scientific literature.

In summary, the results of this analysis not only highlight the main sources of knowledge in smart city development, but also underscore the importance of maintaining a balanced approach between technological innovation and urban sustainability. For future research, further diversification in publications and interdisciplinary collaboration will be essential for further progress in this evolving field.

RQ3: Which countries most frequently co-occur in research on the development framework and its influence on smart cities?

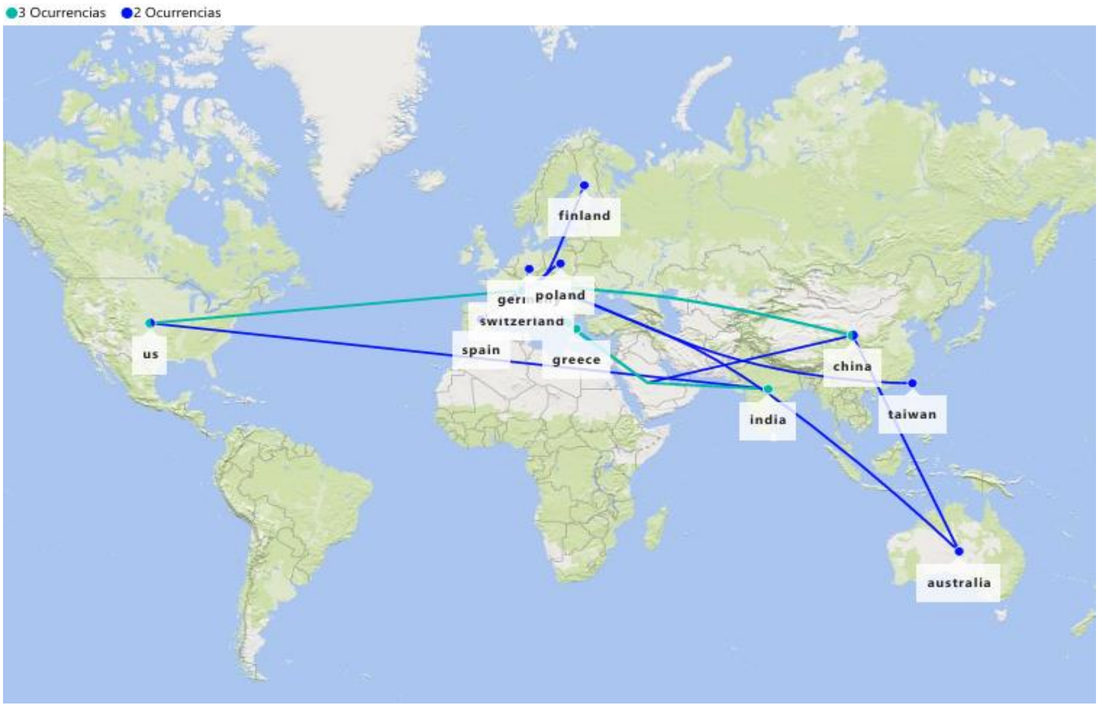

Fig 8: Concurrent Keyword

To address the research question of which countries most frequently show co-occurrence in research related to the development framework and its influence on smart cities, a specific algorithm was implemented to calculate co-occurrence between nations. This methodological approach not only allows us to identify the main actors in the field, but also to understand the dynamics of international collaboration and established knowledge networks.

The process started with the construction of a co-occurrence matrix of size $n \times n$, where n represents the number of relevant countries in the analyzed publications. Each time two countries were mentioned in the same study, the corresponding value in the matrix increased by one unit, thus establishing direct connections between them. Subsequently, a normalization was applied by dividing each value by the total number of articles reviewed (N), obtaining a relative measure of the frequency of co-occurrence. To evaluate the similarity between countries, the Jaccard coefficient was used, expressed as:

$$sim(i, j) = M(i, j) / (M(i, i) + M(j, j) - M(i, j))$$

Where $M(i,j)$ M(i,j) represents the co-occurrence between countries i and j, while $M(i,i)$ and M(j,j) reflect the self-co-occurrence of each country. This indicator made it possible to identify the strength of bilateral relations in terms of joint scientific production.

The analysis revealed that the countries with the highest frequency of co-occurrence tend to be those with a long track record in technological innovation and sustainable urban development. In addition, international collaboration networks were predominantly among countries with developed economies, suggesting privileged access to financial, technological and academic resources. However, there was also evidence of a growing participation of emerging nations, particularly in Asia and Latin America, which are seeking to strengthen their capacities in the transformation towards smart cities through strategic partnerships.

A relevant aspect identified in Figure 8 is the existence of clearly delimited collaborative communities, where certain nations act as central nodes in the research network. Countries such as the United States, China and Germany stood out for their high connectivity, serving as key links in the transfer of knowledge and technologies. These interactions not only drive the development of innovative solutions, but also generate opportunities for the internationalization of urban policies and strategies.

On the other hand, the limited participation of some underdeveloped countries shows inequalities in scientific production and access to collaboration networks. This raises the need to promote initiatives that encourage the inclusion of less represented regions in joint research projects, thus strengthening diversity and equity in academia. Furthermore, the analysis of co-occurrence between countries not only provides a clear view of the main collaborations in the field of smart cities, but also highlights the existing gaps. For future research, it would be pertinent to explore the factors that influence the formation of these networks, as well as to assess the impact of international cooperation on the effective implementation of urban development frameworks. This approach will contribute to consolidating a more equitable and collaborative knowledge ecosystem at the global level.

On the other hand, it is revealed that the United States, China and Australia are the main nodes of co-occurrence, which evidences their outstanding participation in international collaborations in the field of smart city development. Their central position in the academic collaboration network indicates not only a high level of scientific productivity, but also a significant capacity to lead and coordinate joint research at a global level. In Europe, countries such as Germany, Poland and Switzerland maintain strong connections, reflecting a collaborative approach to urban innovation and technological research. Prominent links between the United States and Europe, as well as between China and Australia, suggest the formation of strategic alliances that drive knowledge exchange and technological advancement in smart cities.

Compared to previous studies, discrepancies are observed in the identification of the most productive countries. For example, research by (Kousis & Tjortjis, 2021) highlighted China as the top contributor to systematic review, followed by the United States and Spain. This underscores China's influence on scientific production and its commitment to urban transformation. On the other hand, the study by (Szum, 2021) took a different perspective, identifying India as the most productive country, followed by the United States and China. However, in the present analysis, India shows a limited contribution, suggesting that the conclusions may vary significantly depending on the selection criteria and databases used. Similarly, (Christofi et al., 2021; Pollach, 2012) identified Italy as the main contributing country in their review, although in this research its presence is marginal. These discrepancies highlight the importance of considering methodology, database coverage and inclusion criteria when interpreting co-occurrence results.

The prominent presence of the United States and China not only reflects their scientific production capacity, but also their role as leaders in the global smart city's agenda. Their influence extends beyond their own borders, fostering collaborations with other countries and promoting the transfer of knowledge and technologies. Europe, for its part, has consolidated a collaborative research ecosystem, with internal connections that strengthen regional integration and generate synergies around sustainable urban initiatives. This dynamic of transnational cooperation facilitates the development of innovative solutions and the effective implementation of public policies in the context of smart cities.

For researchers and academics, understanding these collaborative flows is essential to establish strategic alliances with established research groups. In addition, identifying the main nodes of co-occurrence provides a clear vision of existing opportunities to strengthen knowledge exchanges and academic practices. In this sense, the promotion of inclusive and diversified research networks would contribute to closing existing gaps, allowing more countries to actively participate in the construction of knowledge on smart cities.

This analysis also raises the need to promote greater equity in scientific collaboration. Although countries with greater technological and financial capacity lead the way in the production of knowledge, it is imperative to promote mechanisms that facilitate the participation of emerging economies. The development of international cooperation platforms and equitable access to research resources can have a positive impact on the democratization of knowledge and the application of sustainable solutions in global urban contexts. This critical perspective allows not only to understand the current dynamics of collaboration, but also to project strategies that strengthen future research in the field of smart cities.

RQ4: Which papers on the development framework and its impact on smart cities have conclusions characterized by high objectivity and moderate polarity?

To address research question RQ4, a polarity and objectivity analysis of the selected articles was performed, complemented by the number of citations received. This approach makes it possible to identify studies that present balanced, substantiated conclusions of high methodological quality in relation to the development of smart cities. The evaluation of these parameters facilitates the identification of research with high academic impact and practical relevance, providing a clear view of the main scientific contributions in this field. Figure 9 illustrates the results of this analysis, highlighting the distribution of articles by country and their influence on the advancement of knowledge on urban development frameworks.

Country	Tot Papers	No Citations	Avg Objectivity	Avg Polarity	Cita/ Peper	H-Index
South Korea	4	285	0,60	0,08	71	397
UK	3	256	0,44	0,13	85	487
Finland	2	73	0,66	0,06	37	200
Greece	4	73	0,60	0,11	18	427
India	9	66	0,51	0,04	7	770
Australia	5	61	0,38	0,03	12	482
China	5	55	0,46	-0,08	11	914
Cyprus	1	54	0,39	0,16	54	132
Denmark	1	34	0,58	0,04	34	85
Germany	2	33	0,57	0,09	17	340
Malaysia	1	33	0,49	0,14	33	204
South Africa	1	21	0,45	0,06	21	103

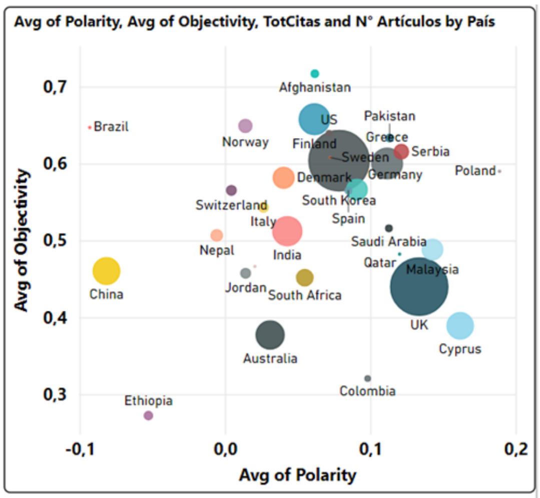

Fig 9: Objectivity and Polarity

To address the assessment of objectivity and polarity presented in Figure 9, an approach based on text analysis using natural language processing (NLP) techniques was used. In particular, tools such as TextBlob and VADER (Valence Aware Dictionary and sEntiment Reasoner) were applied, which allow quantitative metrics to be extracted from the content of the conclusions of the articles reviewed. Polarity was measured on a continuous scale from -1 to 1, where negative values indicate a predominantly pessimistic or critical tone, while positive values reflect a more optimistic view. A value close to 0 represents a neutral or moderate tone, indicating less emotionally charged or biased conclusions.

On the other hand, objectivity was evaluated on a scale of 0 to 1, where 0 indicates a high degree of subjectivity, reflecting personal opinions or judgments, while 1 corresponds to greater objectivity, characterized by statements supported by evidence and logical reasoning. This analysis was complemented by a review of key terms and the argumentative context, ensuring a more accurate assessment of the nature of the conclusions. In addition, to minimize possible biases in the automatic interpretation, a manual validation of a representative sample of articles was performed, verifying the consistency of the scores assigned by the algorithms. This mixed approach ensured greater robustness and reliability in the results presented in Figure 9, providing a critical and informed view on the quality of the conclusions in the literature analyzed.

In the analysis of polarity and objectivity of research on the development framework and its impact on smart cities, notable differences were identified among the countries evaluated. South Korea and the United Kingdom stand out for their high citation levels (285 and 256 respectively), reflecting a significant impact on the scientific community. Despite presenting moderate levels of polarity, their high objectivity suggests that the conclusions of their studies are perceived as balanced and well-founded. This combination of attributes positions both countries as key references in the advancement of knowledge on smart cities.

On the other hand, Finland, with an objectivity of 0.66, stands out as a highly reliable source despite having a lower number of citations (73). Its evidence-based approach and the construction of objective conclusions make it a model for future research that prioritizes methodological soundness. In contrast, Australia and Cyprus present low levels of objectivity and a polarity more inclined toward optimistic interpretations (with Cyprus reaching a polarity of 0.16). This suggests possible biases or limitations in the analytical rigor of their conclusions, which calls for a critical review of their contributions before assuming them as a referential basis.

Studies such as those by (Abusaada & Elshater, 2021) and (Hájek et al., 2022) employed clusterbased methodologies to segment and analyze groups of investigations with similar approaches. Although their objectives were not strictly comparable to those of this analysis, their application in the identification of thematic patterns is relevant. The ability of clusters to group studies with common characteristics facilitates understanding of prevailing perspectives and areas of debate within the smart cities field. This approach also reveals opportunities for future international collaborations and fosters a holistic view of the urban phenomenon.

In practical terms, the prioritization of studies from countries such as Finland, South Korea and the United Kingdom can strengthen the validity and depth of the literature reviews. However, the presence of less objective countries such as Australia and Cyprus highlights the need for critical analysis when incorporating their findings into future research. These differences in objectivity and polarity underscore the importance of assessing the credibility of sources, ensuring that findings used to inform urban decisions and policies are supported by solid evidence and balanced perspectives. In addition, this analysis guides researchers in identifying potential collaborations with research groups recognized for their methodological excellence and significant contributions to the field.

RQ5: What technologies are used in a development framework for smart cities?

In the context of smart cities, emerging technologies play a key role in facilitating the efficient management of urban resources and improving citizens' quality of life. Smart city development frameworks integrate advanced technological solutions to address complex urban challenges, promoting sustainability, connectivity and innovation. To identify the main technologies employed in these frameworks, a comprehensive analysis of the scientific literature was conducted. This approach allowed us to classify and evaluate the most relevant technologies, highlighting their applicability and frequency of use in various areas such as transportation, energy, security and environmental management. Table 5 presents a detailed overview of these technologies, providing a deeper understanding of their impact on the development of smart cities.

Table 5: Technologies Used

Area	Reference	Qty. (%)
Internet of Things	(Ahuja & Khosla, 2019; AlAli et al., 2023; Ali, 2022; Alsamani et al., 2023; Ansari & Mehrotra, 2019; Apanaviciene et al., 2022; Bernal & Espitaleta, 2021; Bibri, 2021; El Hendy et al., 2022; García-Font, 2021; Gautam et al., 2021; Ghaemi et al., 2018; Giourka et al., 2019; Gomathi et al., 2021; Gong et al., 2019; Ismagilova et al., 2022; Jnr, 2022, Khadidos et al., 2022; Kourtzanidis et al., 2021; Lewandowska & Chodkowska-Miszczuk, 2022; Li et al., 2020; Li et al., 2021; Lim et al., 2018; Linde et al., 2021 Liu et al., 2017; Ma et al., 2020; Makhdoom et al., 2020; Manjunatha & Annappa, 2020; Choi & Kim, 2022; Moustaka et al., 2021; Naqvi et al., 2020; Sabory et al., 2021; Tripathy et al., 2023).	33 (24)
Big Data	(AlAli et al., 2023; Alsamani et al., 2023; Alshuwaikhat et al., 2022; Ansari & Mehrotra, 2019; Apanaviciene et al., 2020; Bernal & Espitaleta, 2021; Chun et al., 2021; Eirinaki et al., 2018; El Hendy et al., 2022; Fahmideh et al., 2021; Gautam et al., 2021; Ghaemi et al., 2018; Giourka et al., 2019; Ismagilova et al., 2022; Khadidos et al., 2022; Kourtzanidis et al., 2021; Lewandowska & Chodkowska-Miszczuk, 2022; Li et al., 2021, Linde et al., 2021; Ma et al., 2020; Makhdoom et al., 2020; Choi & Kim, 2022; Moustaka et al., 2021; Naqvi et al., 2020; Osman, 2019; Qasem et al., 2020; Rani & Chauhdary, 2018; Sabory et al., 2021; Shah et al., 2019; Tripathy et al., 2023; Westraadt & Calitz, 2020).	31 (22)
Cloud Computing	(Ahuja & Khosla, 2019; AlAli et al., 2023; Ansari & Mehrotra, 2019; Apanaviciene et al., 2020; El Hendy et al., 2022; Fahmideh et al., 2021; Garcia-Font, 2021; Gautam et al., 2021; Gomathi et al., 2021; Inac & Oztemel, 2022; Ismagilova et al., 2022; Jnr & Petersen, 2022; Khadidos et al., 2022; Kourtzanidis et al., 2021; Li et al., 2021; Lim et al., 2018; Makhdoom et al., 2020; Manjunatha &	25 (18)

	Annappa, 2020; Choi & Kim, 2022; Moustaka et al., 2021; Naqvi et al., 2020; Osman, 2019; Qasem et al., 2020; Shah et al., 2019; Tripathy et al., 2023).	
Machine Learning	(Abid et al., 2020; Apanaviciene et al., 2020 Chun et al., 2021; Eirinaki et al., 2018; Garcia-Font, 2021; Gautam et al., 2021; Ismagilova et al., 2022; Jnr & Petersen, 2022; Kourtzanidis et al., 2021; Kuru & Ansell, 2020; Lim et al., 2018; Ma et al., 2020; Makhdoom et al., 2020; Manjunatha & Annappa, 2020; Mei et al., 2017; Naqvi et al., 2020; Osman, 2019; Paricio & Lopez-Carmona, 2019; Petrović & Koćić, 2020; Qasem et al., 2020; Rani & Chauhdary, 2018).	22 (16)
Artificial Intelligence	(Alfouzan et al., 2022; Angelakoglou et al., 2019; Barnwal et al., 2019; Chauhan et al., 2020; De Sanctis et al., 2022; Oh, 2020; Ismagilova, 2022; Li et al., 2021; Makhdoom et al., 2020; Malkawi et al., 2022; Manjunatha & Annappa, 2020; Moustaka et al., 2021; Naqvi et al., 2020; Osman, 2019; Sabory et al., 2021, Teixeira & Rezende, 2023; Tripathy et al., 2023).	18 (13)
Blockchain	(Apanaviciene et al., 2020; Garcia-Font, 2021; Gong et al., 2019; Ismagilova et al., 2022; Jnr & Petersen, 2022; Kourtzanidis et al., 2021; Lim et al., 2018; Malkawi et al., 2022; Moustaka et al., 2021; Tanda & De Marco, 2019; Paricio & Lopez-Carmona, 2019).	11 (7)

In order to critically address the use of technologies in the development of smart cities, it is essential not only to identify the main tools, but also to evaluate their implementation challenges and consider the contextual factors that condition their adoption. The Internet of Things (IoT) leads with 24% of representation, consolidating itself as the essential technology for the collection and transmission of data in real time. Its application in urban infrastructures, transportation systems and environmental monitoring enables efficient and automated management of public services. However, its implementation faces challenges related to device interoperability, cybersecurity and the protection of citizens' privacy, critical aspects that require solid regulatory frameworks and advanced security solutions.

On the other hand, Big Data, with 22%, plays a strategic role in the aggregation and massive analysis of urban information. Its ability to identify patterns and predict behaviors facilitates data-driven decision making. However, data quality, the integration of multiple sources and the need for robust computational infrastructure are relevant obstacles. In addition, governments and urban managers face the challenge of balancing access to data with the protection of privacy and security, especially in environments where surveillance and control can be controversial.

Cloud Computing and Machine Learning, with 18% and 16% respectively, reflect the growing reliance on scalable platforms and predictive models for optimizing urban processes. While Cloud Computing offers flexible storage and processing at large scale, Machine Learning allows automating decisions and detecting anomalies in real time. However, migration to the cloud involves security risks, technological dependency and associated costs, especially for cities with limited budgets. Also, the implementation of machine learning algorithms can generate biases or non-transparent decisions, which underlines the importance of applying principles of ethics and algorithmic accountability.

Despite their lower presence, technologies such as Artificial Intelligence (AI) (13%) and Blockchain (7%) show disruptive potential in urban management. AI facilitates the automation of complex tasks, image recognition and the personalization of public services. However, the lack of regulation and concerns about the concentration of power in the hands of large technology corporations pose significant challenges. For its part, blockchain offers innovative solutions for data security and transaction traceability, especially in digital identity management systems, property registries and smart contracts. However, its large-scale adoption still faces limitations related to scalability, energy consumption and institutional acceptance.

Myeong et al. (2022) highlighted the need for a balanced technological implementation, noting that the success of smart cities lies not only in the application of advanced technologies, but in the creation of inclusive and sustainable governance models. Along these lines, Yigitcanlar et al. (2018)

warned about the risks of an overly technological approach that neglects social, cultural and environmental aspects. Overreliance on technological solutions can generate digital exclusion, social gaps and loss of autonomy of local governments vis-à-vis multinational technology companies.

In short, although IoT and Big Data continue to lead as technological pillars in the development of smart cities, the integration of emerging technologies such as AI and Blockchain poses both opportunities and challenges. The effective implementation of these technologies will depend not only on their technical capacity, but also on the creation of sound public policies, investment in digital infrastructure, and the promotion of an inclusive innovation ecosystem. This analysis underscores the need for an interdisciplinary approach that considers social, economic and environmental factors, thus ensuring equitable and sustainable urban development.

4.3. Critical Synthesis of Findings

To provide an integrated and critical view of the findings obtained in this research, the main results of each research question are synthesized, analyzing their implications and contributions to the field of smart cities.

In terms of academic quality and relevance (RQ1), the predominance of publications in high impact journals (Q1 and Q2) reflects a growing interest and scientific recognition in the development of frameworks for smart cities. This positioning in prestigious journals not only validates the relevance of the topic, but also raises the need to deepen applied studies that go beyond the theoretical realm and address practical challenges in diverse urban contexts. However, the scarce presence of publications in lower quartile journals suggests an opportunity to broaden the scope of knowledge towards more inclusive dissemination platforms, allowing the participation of researchers from emerging regions.

Regarding the most prolific publications (RQ2), there was an evident dominance of journals such as Sustainability, Sensors and IEEE Access, which evidences a multidisciplinary approach where sustainability, technology and innovation are addressed in an integrated manner. However, this concentration also reflects a reliance on traditional areas of technological research, leaving room for studies that prioritize social, cultural and political aspects. The lack of publications in journals specializing in urban governance or citizen participation suggests the need for more cross-cutting research that considers the human dimensions of smart cities.

The co-occurrence analysis by country (RQ3) shows the United States, China and Australia as key players in smart cities research and development, establishing strategic alliances and leading global scientific production. This leadership translates into the generation of high-impact knowledge, but also exposes a concentration of influence that could limit the diversity of perspectives. In contrast, the lower representation of developing countries points to gaps in international collaboration and raises the need to foster more inclusive academic networks that expand knowledge transfer to regions with fewer technological resources.

In terms of objectivity and polarity of conclusions (RQ4), it became evident that nations such as Finland and Greece stand out for their highly objective approaches, which reinforces the reliability of their studies. On the other hand, South Korea and the United Kingdom stand out for their remarkable number of citations and a balance in the polarity of their conclusions, which gives them significant influence in shaping the academic agenda. However, the low objectivity and the presence of conclusions with marked polarity in countries such as Australia and Cyprus are evidence of possible biases or insufficiently substantiated interpretations. This lack of analytical rigor could limit the applicability of their results, especially in contexts where decisions based on scientific evidence are required.

Finally, in relation to the technologies used in the development frameworks (RQ5), the predominance of the Internet of Things (IoT) and Big Data as the main technological tools underlines the relevance of monitoring systems and real-time data management. Their effective application has proven to optimize urban services, from transportation to waste management. However, their reliance on robust infrastructures and advanced communication networks poses significant challenges for resource-constrained cities. The growing adoption of Cloud Computing and Machine Learning highlights the importance of predictive models and scalable platforms, although their application may be conditioned by ethical constraints and risks associated with data privacy.

On the other hand, the low presence of technologies such as Artificial Intelligence (AI) and Blockchain reflects an opportunity to explore innovative solutions that strengthen security, automation and transparency in urban management. However, their limited adoption can also be attributed to regulatory barriers and lack of technical capabilities in many cities. Effective integration of these technologies requires strong regulatory frameworks and greater collaboration between governments, academic institutions and technology companies.

In summary, the findings of this research not only highlight the main trends in the development of smart cities, but also highlight the existing gaps in terms of technological equity, methodological rigor and geographic diversity. To move towards more effective and sustainable implementation, it is essential to promote interdisciplinary research, strengthen international collaboration, and ensure that the benefits of smart cities are distributed equitably. This critical analysis provides a solid foundation for future research and contributes to the design of more inclusive and evidence-based public policies.

5. Conclusions and Future Research

This research provided an exhaustive and critical analysis of the publication patterns, technological implementation and impact of development frameworks in smart cities, addressing in an integrated manner several fundamental questions for the advancement of knowledge in this emerging area. The results obtained allow us to draw relevant conclusions that highlight not only the strengths observed, but also the critical areas that require attention and deepening in future research.

First, with respect to the quartile levels of the journals that have published research on the impact of the smart cities development framework (RQ1), it was identified that most of the studies analyzed are predominantly concentrated in journals in the first two quartiles (Q1 and Q2). This trend evidences the academic recognition of the topic and its positioning within the highest quality scientific publications, suggesting methodological soundness and growing rigor in the field. However, the scarce presence in lower impact journals could limit the accessibility of knowledge to emerging researchers or academic institutions with fewer resources, which opens an opportunity for future research that promotes the democratization of knowledge and a more inclusive dissemination of results
(Szum, 2021; Barberán et al., 2012).

Secondly, when addressing the most prolific publications in this field (RQ2), key journals such as Sustainability, Sensors and IEEE Access were identified. This result reflects an interdisciplinary approach focused mainly on urban sustainability and advanced technological applications. Despite the substantial contribution of these journals, there was a deficiency in the representation of studies focused on social, ethical and cultural aspects of smart urban development, which represents a substantial gap that future research should fill. It would be relevant to broaden the contributions from disciplines such as social sciences, humanities and urban governance to provide a more holistic and balanced perspective of the studied phenomenon (Tripathy et al., 2023; Gomma & Fahmy, 2013).

Third, when analyzing country co-occurrences (RQ3), the United States, China and Australia emerged as preponderant actors, highlighting a strong international collaboration, mainly oriented towards Europe and Asia. However, the limited participation of developing regions reflects a significant asymmetry in the geographic distribution of knowledge, which could result in a bias towards urban realities of more developed economies. Future research should foster more diverse and inclusive collaborations, facilitating technology transfer to countries with fewer resources, and enabling the creation of urban solutions adapted to heterogeneous socioeconomic contexts (Rani &

Kumar, 2022).

Regarding objectivity and polarity in the conclusions of the studies analyzed (RQ4), it was found that Finland and Greece offer research with a high degree of objectivity, although with fewer citations received. On the other hand, countries such as the United Kingdom and South Korea combine high citations with relatively balanced conclusions, suggesting a strong academic influence. However, some studies from Australia and Cyprus were found to have low levels of objectivity, revealing potential methodological weaknesses or interpretive biases. These differences underscore the critical importance of rigorously evaluating sources when selecting theoretical and empirical bases for future research (Osman, 2019).

In terms of the technologies identified in the smart city development frameworks (RQ5), it became clear that the predominant technologies are Internet of Things (IoT), Big Data, and Cloud Computing. While these technologies provide a solid technical foundation, their implementation faces significant challenges, such as interoperability between heterogeneous systems, the need for robust protection of personal data, and high upfront costs. Moderate growth was observed in the use of Artificial Intelligence and Blockchain, emerging technologies that could solve specific problems related to the safety and efficiency of urban services, but whose widespread adoption requires resolving pending technical, regulatory, and ethical barriers (Manjunatha & Annappa, 2020; Malkawi et al., 2022).

This systematic review presented some limitations beyond methodological ones, such as the restriction of languages used, the exclusion of gray literature, as well as the concentration on predominant academic databases. These decisions may have resulted in a limited representation of certain regions and alternative or emerging approaches. Consequently, future reviews should consider incorporating literature in multiple languages, specific regional databases, and include practical studies or technical reports, in order to generate more inclusive and representative results of actual smart city development (Alfouzan et al., 2022).

Therefore, as a significant and distinctive contribution of this study, the development of a new global conceptual framework, based on the results obtained, is proposed. This framework should integrate technological, social, economic and political factors, providing clear and structured guidelines to guide both future academic research and practical applications in various urban contexts. This new conceptual framework would allow better guidance for future studies and provide a more holistic approach that recognizes both the potential benefits and limitations inherent in the digital transformation of cities. In this sense, future research should focus not only on emerging technologies, but on the holistic impact these technologies have on real communities, ensuring social inclusion, technological equity and environmental sustainability in smart urban development (Ansari & Mehrotra, 2019).

For future research, it is recommended that efforts be focused on broadening the methodological spectrum and geographic diversification of the knowledge generated in the field of smart cities. It is essential to carry out comparative studies that integrate diverse socioeconomic contexts, especially those belonging to emerging economies or developing countries, to better understand the specific needs and challenges associated with technological implementation in heterogeneous conditions. It is also crucial to address in greater depth the ethical, social and political implications of the intensive use of emerging technologies, promoting interdisciplinary research that considers approaches from the social sciences, humanities and urban governance (Barnwal et al., 2019).

Finally, the development of an updated conceptual framework that integrates in a balanced manner both technological aspects and human and environmental dimensions is suggested. This new framework should consider the active participation of diverse social actors, including local governments, community organizations and citizens, in the definition of technological priorities and public policies associated with smart urban development. This will ensure that the proposed solutions are not only technically feasible, but also socially inclusive, economically accessible and environmentally sustainable, thus contributing to a more equitable and responsible urban development at a global level (Fahmideh et al., 2021; Eirinaki et al., 2018).

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